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Proposed Quality Improvement of Clutch Disc Products Using Statistical Quality Control and Fault Tree Analysis Methods at PT. Exedy Manufacturing Indonesia

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Abstract

PT. Exedy Manufacturing Indonesia is an automotive industry company that produces Clutch Assy Wheel 4 – Wheel 2 Clutch / Clutch, E. Spring, RLS Plate Motorcycle. Their average production capacity is 1,103 units of clutch discs per day. The company has a product defect standard that cannot exceed 3%, but currently, the average rate of product defects reaches 10%. There are three highest numbers of defective products, consisting of 609 units of consumable blades, 533 units of small size, and 571 units of uneven surface. This means that the quality control carried out by the company is still not optimal and needs improvement. This study aims to determine the number and the causes of defects and quality improvement using statistical quality control (SQC) and fault tree analysis (FTA) methods. From the SQC, it shows that 4 data exceed the upper control limit thus improvements need to be made. The results of the FTA method showed there are 10 basic events in determining the cut set, namely poor material quality, lack of experience, poor work procedures, fatigue, lack of skill, haste, air temperature, poor lighting, untidy area, and shrinking machine performance. Then a proposal for improvement is made to improve the factors that influence the cause of the defect.

Keywords: Fault Tree Analysis, Quality Improvement, Statistical Quality Control

Introduction

At this time, the competition in the world of the manufacturing industry is getting tighter, because one type of product is produced by several different manufacturing companies. The rapid development of the industrial world in various fields increases competition, especially for companies that produce similar goods. The company itself must have a competitive advantage in facing the competition in the industrial world to survive in the competition. The number of companies that produce similar goods makes consumers more selective in choosing the best quality products. Research shows that product quality is one of the main factors affecting consumer satisfaction (1–3). When consumers are satisfied with the resulting product, it will affect loyalty to a brand (4,5). Even in the long term, this consumer

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loyalty can be an effective promotional tool, because satisfied customers will tell others about the products purchased (6). One of the activities in creating a quality product to suit consumer desires is to implement appropriate quality control, having very clear goals and stages, so that it can provide innovation in the prevention and resolution of problems that exist in improving quality products.

Quality is a dynamic condition associated with products, services, people, processes, and the environment that meet or exceed expectations (7). Quality control and quality are one of the most important functions of a company. With good quality control and quality, the percentage of product defects can be reduced as little as possible so that the company gets greater profits (8). Quality control is a process control activity for the characteristics of an item or product, comparing it with specifications or requirements, and taking appropriate corrective action if there is a difference between a current product with a standard product. Quality control is an effort to maintain the quality of the goods produced so that they are following the product specifications that have been determined based on the company's leadership policies. The number of defective products in a production process will have an impact on losses for the company's costs. So, companies need to plan to minimize the number of defective products in the future. The company's plan needs to be made is to find a way to control product quality.

PT Exedy Manufacturing Indonesia is a company engaged in the automotive industry, established on October 2012, with a total of 752 employees producing Clutch Assy Wheel 4 – Wheel 2 Clutch / Clutch, E.Spring, RLS Plate Motorcycle. PT Exedy Manufacturing Indonesia meets the needs of local and international markets. One of the products that I observed myself was the Clutch Disc (clutch plate), one of the parts for the car clutch. The function of the clutch plate itself was to transmit power from the flywheel to the transmission. Production capacity at PT Exedy Manufacturing itself can produce 1.103 units per day and defective products reach 70 to 90 units/per day. The defect consists of too small diameter, rough surface, and uneven surface. The number of defective products reaches 10%, which of this amount exceeds the tolerance targeted by the company by 3% of the total production for defective products. Based on these numbers in terms of quality control owned by the company is still not optimal, so improvements are needed in quality control of Clutch Disc products (clutch plates) for car clutch products produced by the company to be better.

Much research on quality improvement has been carried out previously with various methods, such as using FMEA(9), kaizen(10), six sigma(11), SQC (12), and so on. This study intends to overcome the occurrence of product defects by quality control using Statistical Quality Control and it is hoped that this method can reduce the number of defects in the production process and can minimize and improve product quality by the company. There are several methods to improve product quality control that can be used, one of which is Fault Tree Analysis (13). FTA is an analytical method that can analyze a system failure, can look for aspects of the system involved in the main failure, and find the causes of defects in the production process. This method is expected to be an alternative to improve product quality and improve product quality produced during the company's production process.

Method

This research was conducted using secondary data. The data obtained is rejected products produced by the company for one month through direct research at PT. Exedy Manufacturing Indonesia. The data obtained is then processed using statistical quality control methods and fault tree analysis.

Quality control Statistical Quality Control (SQC) according to experts, is a statistical technique that is widely used to ensure that processes meet standards, Heizer and Render (2004). Quality Control Statistical Quality Control has 5 main statistical tools that can be used as tools to control quality, namely: Check sheet, Histogram Diagram, Pareto Diagram, Control Map (P-Chart), and Fishbone Diagram.

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Fault Tree Analysis is an analytical tool that translates graphically the combinations of errors that cause a system failure. This technique is useful in describing and assessing the events that occur in the system. Fault Tree Analysis is effective in finding the core of the problem because it ensures that an unwanted event or loss does not originate at a single point of failure. Fault Tree Analysis identifies the relationship between causal factors and is displayed in the form of a fault tree involving logic gates. There are 5 stages to analyze with Fault Tree Analysis (FTA), including identifying problems and boundary conditions of a target system, Depicting the Fault Tree graphic model, Finding the minimum cut set from Fault Tree analysis, Performing qualitative analysis of the Fault Tree, Performing quantitative analysis of Fault Tree.

Result and Discussion

The first step in data processing is to identify product defects using statistical quality control consisting of check sheets, histogram diagrams, Pareto diagrams, Control Maps (P-Charts), and fishbone diagrams. The next step is to make a suggestion for improvement using fault tree analysis.

In carrying out statistical quality control, the first step is to make a check sheet. Check sheets are useful to simplify the process of data collection and analysis. The results of data collection through check sheets that have been carried out can be seen in Table 1.

Table 1. Check Sheet

Date	Production Quantity (sheet)	Reject Quantity	Type of Defect			Percentage *Reject* (%)
			Size	Surface	Cutting	
4/01/2	1103	110	30	35	45	9.973
5/01/21	1103	58	12	25	21	5.258
6/01/21	1103	70	27	21	22	6.346
7/01/21	1103	85	15	45	25	7.706
8/01/21	1103	60	20	12	28	5.440
9/01/2	1103	147	58	41	48	13.333
11/01/2	1103	85	13	33	39	7.706
12/01/2	1103	75	22	28	25	6.800
13/01/2	1103	45	10	15	20	4.080
14/01/2	1103	25	8	7	10	2.267
15/01/2	1103	30	6	14	10	2.720
16/01/2	1103	30	7	10	13	2.720
18/01/2	1103	25	15	6	4	2.267
19/01/2	1103	45	16	8	21	4.080
20/01/2	1103	30	10	10	10	2.720
21/01/2	1103	60	23	12	25	5.440
22/01/2	1103	75	45	15	15	6.800
23/01/2	1103	108	25	58	25	9.791
25/01/2	1103	111	35	55	21	10.063
26/01/2	1103	60	15	16	29	5.440
27/01/2	1103	45	20	15	10	4.080
28/01/2	1103	75	29	32	14	6.800
29/01/2	1103	71	21	30	20	6.437
30/01/2	1103	63	6	32	25	5.712
1/02/21	1103	70	20	20	30	6.346
2/02/21	1103	55	25	14	16	4.986
Total	2867	1713	53	60	57	

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The data on the check sheet is the result of collecting data from 26 working days. As can be seen in Table 1, there are three types of defects consisting of size defects, surface defects, and cutting defects. Data regarding the percentage of rejects also shows that the number of rejects per day is much larger than the standard set by the company (3%).

From the results of the check sheet, a histogram diagram can then be made to show a comparison of the number of existing defects. The histogram can be seen in Figure 1. From the histogram it can be concluded that the largest number of defects occurs in surface defects, followed by cutting and size.

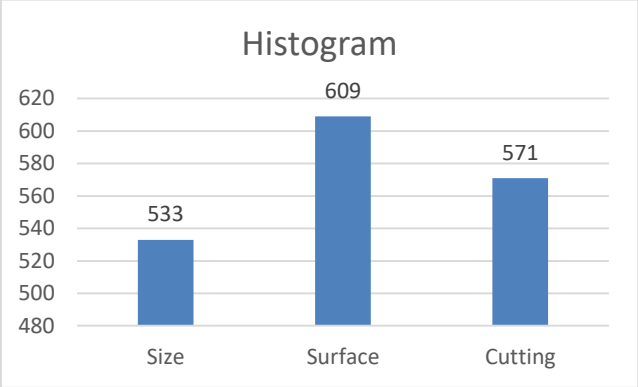

Figure 1 Histogram

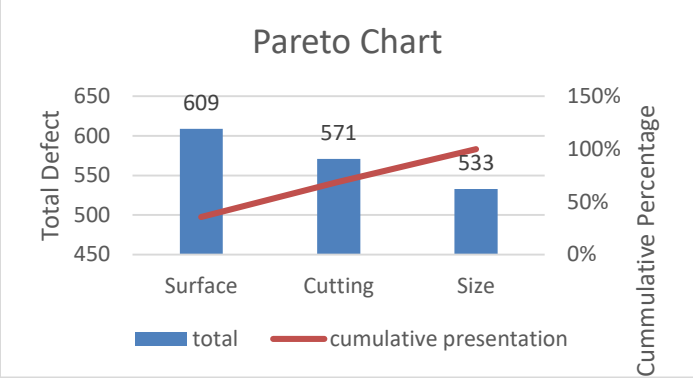

Figure 2 Pareto Chart

A Pareto diagram can then be created based on the results of data collection. By making a Pareto diagram, it can be determined which problem is the most important and must be solved immediately. From Figure 2 it can be concluded that improvements can be focused on the cause of the rough surface in the clutch disc manufacturing process because it has the highest percentage of defects compared to other defects.

The next step in performing statistical quality control is to create a control chart. The control chart is made by calculating the percentage of rejects per day, then continued by calculating the Central Line (CL), Upper Control Limit (UCL), and Lower Control Limit (LCL). A recap of the calculation results can be seen in table 2. Then, based on the calculation results, a control chart can be made, as can be seen in Figure 3. Figure 3 shows that several points cross the UCL and LCL limits. This shows that there are still many production defects at PT. Exedy Manufacturing crosses control limits. Thus, the company needs to carry out supervision and improvement in quality control so that production results are better and maximum.

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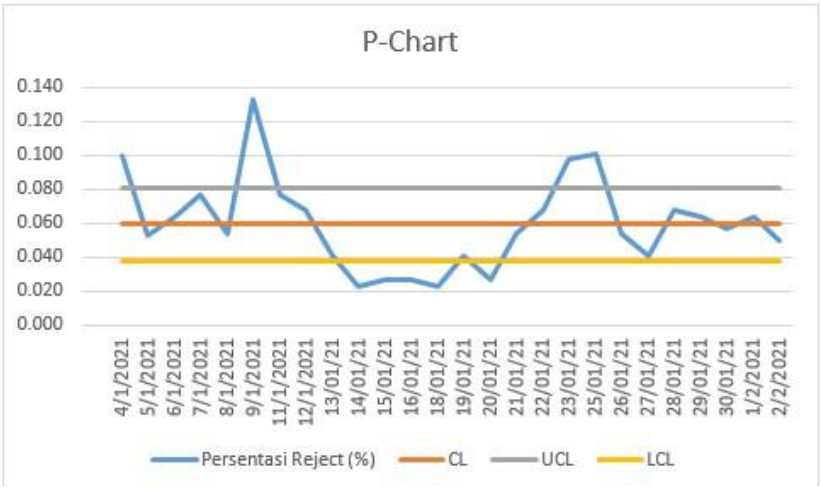

Figure 3 P-Chart

Table 2 Recap of Control Chart Calculation

Date	Total Production	Total Reject	Reject Percentage
04/01/2021	1103	110	0,100
05/01/2021	1103	58	0,053
06/01/2021	1103	70	0,063
07/01/2021	1103	85	0,077
08/01/2021	1103	60	0,054
09/01/2021	1103	147	0,133
11/01/2021	1103	85	0,077
12/01/2021	1103	75	0,068
13/01/2021	1103	45	0,041
14/01/2021	1103	25	0,023
15/01/2021	1103	30	0,027
16/01/2021	1103	30	0,027
18/01/2021	1103	25	0,023
19/01/2021	1103	45	0,041
20/01/2021	1103	30	0,027
21/01/2021	1103	60	0,054
22/01/2021	1103	75	0,068
23/01/2021	1103	108	0,098
25/01/2021	1103	111	0,101
26/01/2021	1103	60	0,054
27/01/2021	1103	45	0,041
28/01/2021	1103	75	0,068
29/01/2021	1103	71	0,064

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30/01/2021	1103	63	0,057
01/02/2021	1103	70	0,063
02/02/2021	1103	55	0,050
CL	0,06		
UCL	0,081		
LCL	0,038		

Action and improvement steps will be easier to do if the problem and the root cause of the problem have been found. A tool that can be used to assist in the analysis of the root cause of the problem is the fishbone diagram. Fishbone diagrams will identify various potential causes of an effect or problem, and analyze the problem through brainstorming sessions. Problems will be broken down into some related categories, including people, materials, machines, procedures, policies, and so on. Cause and effect diagram analysis at PT. Exedy Manufacturing Indonesia, namely:

a. Human Factor, the human factor is one of the most active factors. This can be influenced by several reasons, namely fatigue, no training, and being in a hurry, causing the Clutch Disc printing production process to be less than optimal.
b. Machine Factor, the machine factor is one of the important factors because the machine is a tool used to carry out all activities of the production process. This can be influenced by several things that are influenced by several reasons, namely lack of maintenance, and shrinkage of engine performance.
c. Material Factor, Materials play an important role in the course of the production process from the start. The use of poor-quality raw materials will of course produce bad products. So one of the potential causes of a large number of production defects is that the quality check of raw materials has not been maximized.
d. Method Factor is a procedure for the production process, where a method that works well can produce a good performance. Several things are factors that cause disability, including lack of experience, and lack of supervision, which can be an obstacle to a production process to produce a good product.
e. Environmental factors are one of the things that affect the quality of the products produced. This is because a good environment can provide a sense of security and comfort for operators so that they can support the production process. The environmental factors that affect the current production process at the company are hot air temperatures reaching 27-28 C, poor lighting, and untidy areas.

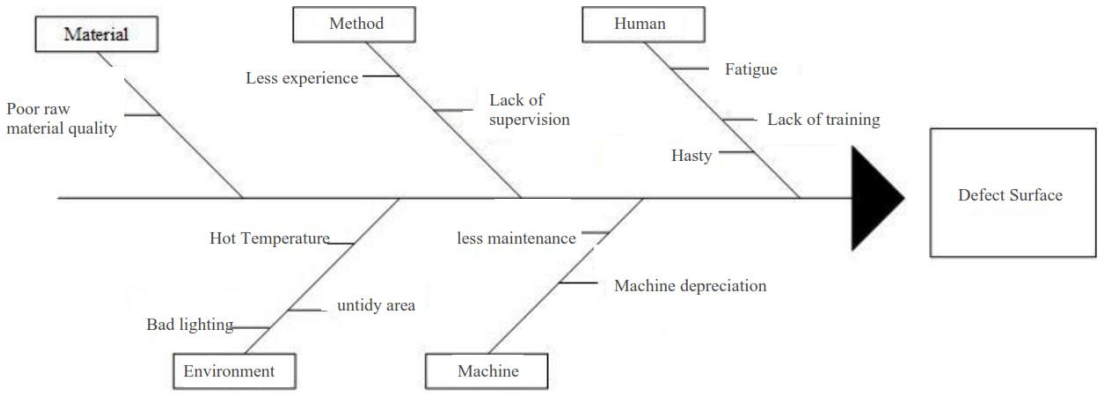

Figure 4 Fishbone Diagram

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After knowing the defect which is the main focus in making repairs to the Clutch Disc product (clutch plate). Then next look for the root cause of the defect by using Fault Tree Analysis to find out what factors are the cause of the defect. The FTE chart and its description can be seen in Figure 5 and

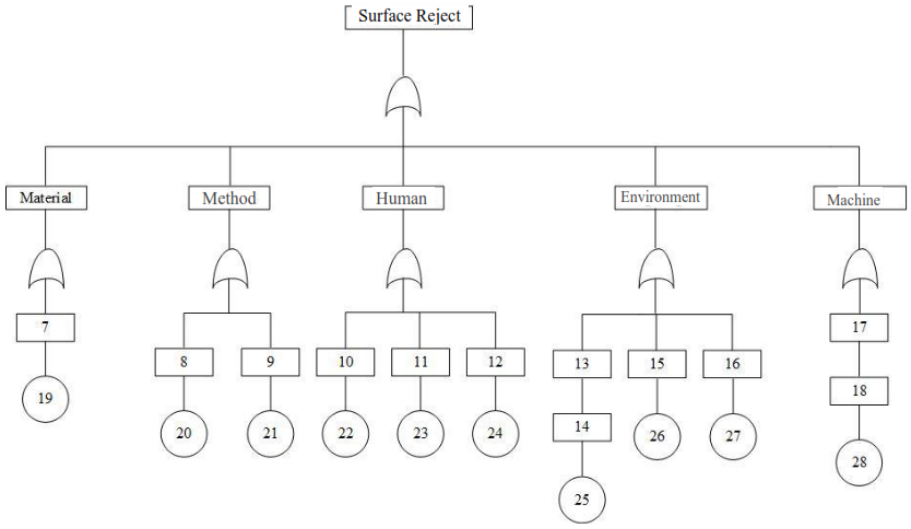

Figure 5 Fault Tree Analysis

Table 3 FTE Chart Description

Code	Description	Code	Description
1	Defect Surface	15	dark
2	Material	16	*Back Tracking*
3	Method	17	Less Maintenance
4	Human	18	Engine Performance
5	Environment	19	Different Levels of Iron Compounds
6	Machine	20	Insufficient Flying Hours
7	Poor Raw Material Quality	21	Bad Work Procedure
8	Less Experience	22	Fatigue
9	Lack of Supervision	23	Lack of Skill
10	Lack of rest	24	Hasty
11	Lack of Training	25	Hot
12	*Wasting Time*	26	Bad Lighting
13	*Air Temperature*	27	Untidy Area
14	Lack of ventilation	28	Out of Blade

From the results of the Pareto diagram, the rough surface defect in the Clutch Disc production process (coupling plate) is the highest with a percentage that is 89%. Therefore, the percentage of rough surfaces is more than half of the types of defects produced, so this type of defect will be discussed for the problems generated by being discussed and analyzed using Fault Tree Analysis. Thus, the top-level event to be analyzed is a rough surface.

The minimum cut-set for the Fault Tree Analysis image above is as follows:

$$Top\ Event = 1$$
$$= 2 + 3 + 4 + 5 + 6$$
$$= [7] + 8 + 9\} + [10 + 11 + 12] + [13 + 14 + 15 + 16] + [17 + 18]$$
$$= [19 + [20 + 21] + [22 + 23 + 24] + [25 + 26 + 27] + [28]$$

The results of the cut-set obtained 10 basic events that cause defects on rough surfaces. It can be seen in Table 4.

Table 4 basic Event

Code	Basic Event	Code	Basic Event
19	Different Levels of Iron Compounds	24	Hasty
20	Less Experience	25	Hot
21	Bad Work Procedure	26	Bad Lighting
22	Fatigue	27	Untidy Area
23	Lack of Skill	28	Out of Blade

From the data that has been known through the determination of the cut set, the factors that influence the occurrence of product defects during the production process based on the results of fault tree analysis can be known. so the next step is to make an improvement plan as Table 5.

Table 5 maintenance plan

Code	Factor	*Basic Event*	Improvement
19	Poor Material Quality	Different levels of iron compounds	Conduct periodic checks when materials arrive.
20	Less Experience	Less Experience	Looking for employees according to their area of expertise.
21	Lack of supervision	Bad Work Procedure	Periodic supervision is required during the production process
22	Fatigue	Lack of rest	- There is a minimum shifting of 3x a day.
			- Need to do regular checkups
23	No training	Lack of Skill	- Training for operator candidates is carried out at least one month before the prospective employee is accepted.
			- It is necessary to conduct training for operators at least three times a month.
24	Hasty	*Wasting time*	- Work according to the time set by the company
			- Provide advice and warnings about the work guidelines set in the company
25	Air Temperature	Lack of ventilation, hot	Adding windows and exhaust fans, especially in the production section
26	Bad Lighting	Dark	The need for additional lamps and wattage

			for brightness in the workspace
27	Untidy Area	*Break tracking*	It is necessary to rearrange the arrangement of production and non-production places, and always check the production site before and after work to make it look neat and comfortable. Application of 5S in the workplace.
28	Less maintenance	Out of Blade	The need for routine maintenance actions on machines and checking tools on machines every day before and after doing work.

Conclusion

1. Quality control on clutch disc products that have been obtained using a histogram diagram with the largest defect being a rough surface with a total of 609 pcs. The P control chart (P-Chart) can be seen that there are still some data that exceeds the upper control limit, so the quality control of clutch disc products is still not optimal, so improvements are needed.
2. The results of the identification that has been carried out, show that the aspects that have the potential to cause the largest number of rejected products are humans, methods, materials, and the environment.
3. From the implementation of the Statistical Quality Control method, the factor that causes the biggest defect is the rough surface. Then an analysis of the causes of defects is carried out using Fault Tree Analysis. The results show that the cause of defects that have occurred is caused by a lack of supervision so periodic supervision and checks are needed during the production process.

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